Corn Storage

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REPORT OF COOPERATIVE RESEARCH ON INSECT CONTROL IN FARM STORED GRAIN

No. I Period--July 1 to Sept. 30, 1941

R. T. Cotton

During the quarter Mr. T. F. Winburn, who was in field charge of the work of the Bureau of Entomology and Plant Quarantine, was called to the Military Service and was succeeded by Mr. George B. Wagner. He in turn resigned to enter commercial work. The work for the coming quarter will be under the direction of Mr. H. H. Walkden.

As a result of the expansion of the research work sponsored by the Commodity Credit Corporation the insect problems in connection with the farm storage of wheat are now being studied in addition to those of corn. Mr. Richard Schwitzgebel has been assigned to work at the new wheat storage site at Hutchinson, Kansas. Mr. Magner is stationed at Urbana to continue the work on corn storage problems while Mr. H. H. Walkden has established headquarters at Ames, Iowa. Mr. Walkden in addition to supervising the work in Illinois and Kansas will conduct the entomological work at the wheat storage site at Jamestown, N. Dakota and will cooperate with state officials in Iowa and other states in the Commercial Corn Area.

In accordance with plans formulated at the meeting held in Ames, Iowa on April 4, 1941, cooperative work on the entomological problems of grain storage has been carried on by a number of state agencies. This report summarizes the work of all agencies insofar as it has reached a stage warranting presentation.

Corn Storage

Turning and Screening*

The turning and screening operation started in November, 1940, has been continued in both Illinois and Iowa with a number of new rigs being put into operation.

The 42" by 24' screens are proving very effective as they are permitting the hikers to run faster and turn more corn in a given time. After bins have been turned it has been found advisable to spray with oil the first three feet of outside wall all the way around the bins, and to sweep out and also oil spray the door way. This treatment traps thousands of grain insects which either fly onto the bins or crawl to the bins from the turning machine or screenings pile. The results obtained are well worth the small quantity of oil used.

It would seem advisable to dispose of screenings locally or if they are shipped by railway to treat them in such a way as to kill the insects. The shipment of infested screenings will result in the infestation of the box car in which they are carried. This infestation is difficult to eradicate and will cause trouble for future shipments of flour or other milled cereal products.

By the end of September 3,391 of 8,440 bins in 16 counties in Illinois had been turned and screened. In several counties more than half the bins have been finished. In Iowa approximately 10 percent have been turned and screened.

It is gratifying to note that the turning and screening operation has been highly successful. With the exception of a few bins that were treated with an old corn sheller, the bins that have been turned are in excellent condition and have required no other treatment for insect control even though some of them were turned nearly a year ago.

Insect Infestation in Corn

In connection with the turning and screening program samples of corn taken from the bottom of the bins were examined for infestation and a record made of the abundance of each species present.

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* Results of turning and screening operations in Illinois from report of T. F. Winburn and J. M. Magner of U. S. Bur. of Entomology and Plant Quarantine, Dr. M. D. Farrar of the Ill. Nat. Hist. Survey and E. V. Dabney of the Ill. A. A. A.

Illinois*

In Illinois during the period July 1 to Sept. 30, the saw-toothed beetle, Oryzaephilus surinamensis L. continued to remain in first place among the insects found in screening samples sent in from the turning sites, in some cases estimated at from 50,000 to 100,000 per sample. The flat grain beetle, hairy fungus beetle, foreign grain beetle and granary weevil were next in importance as shown by the samples examined. Samples from some bins, however, showed no insects present. In samples sent in from Fithian in Vermillion County the granary weevil was quite in evidence. The foreign grain beetles are more numerous in samples coming from the western part of the state. Indian meal moths are greatly reduced in numbers, and it is almost impossible to find live adults where the bins have been surface treated with oil. Untreated bins in the same location even adjacent to treated ones, range from medium to heavy infestations of larvae and adults of the meal moth. Cynaeus angustus was present in considerable numbers at several turning sites visited in Western Illinois during the middle of September.

Iowa**

In Iowa examinations were made of samples taken from 550 bins which were turned and cleaned in July.

Table I presents a summary of data on the relative abundance and distribution of insects, both dead and alive, by counties. It will be noted that 522 of the 550 bins examined contained insects and that in 368 of the bins at least some of the insects were alive. It is worthy of note that generally speaking the percentage of bins containing live insects was greatest in counties in the southern portion of the state and that the percentage of bins containing live insects was lowest in the northwestern portion of the state.

In classifying bins as infested or uninfested, bins containing one live insect are listed as infested the same as those in which samples produced 100 or more live insects. Since many of the bins listed as infested contained very few live insects, data on the number of live insects per sample was summarized in Table 2. It is interesting to note that less than half of the bins classified as having live insects produced more than 10 live insects per sample and since

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* From observations of Winburn, Magner, Farrar, and Dabney.

** Report of the work in Iowa, carried out by the Entomology Section of the Iowa Agr. Exp. Sta. by Geo. C. Decker.

these samples were taken in moist situations on the floor and represent the highest insect concentrations in the bins it seems apparent that, generally speaking, the corn is in pretty good condition and at least two-thirds of the bins in the state are not in danger of going out of condition as a result of insect infestation.

Table 3 presents a summary of the relative abundance of the various species of stored grain pests encountered in the 550 bins examined. It will be noted that the sawtooth beetle and the flat grain beetle, the two common insect pests which are most winter hardy, were taken in the largest number of bins and such insects as the rust-red flour beetle, the rice weevil and the granary weevil, which are comparatively susceptible to low temperatures were not particularly abundant. This seems to substantiate the results of an early spring survey which indicated a relatively high winter mortality for these same insect pests.

Table 4 summarizes the data obtained from samples taken with a five foot probe at the center of the bins before and after the corn was cleaned. It will be noted that by this method of sampling live insects were detected in only 134 bins and that in 49 bins live insects (mostly sawtooth beetles) were taken in probe samples after the corn had been turned and cleaned. This would seem to substantiate the common belief that probe samples will not give a true picture of insect conditions in the bin and will not reveal the presence of insects that may be present in moist corn on the floor of the bin. It would seem however that in all bins where the insect population was so large that it prevented an immediate threat of heating or other serious deterioration of the corn itself, the presence of insects was easily detected in probe samples as well as floor samples.

Table 1

A summary of data on the relative abundance and distribution of insects, dead and alive, by counties, in samples of corn taken from the floors of bins being turned and cleaned July, 1941

County	Number of bins examined	Number of bins infested	Number of bins having live insects	Percent of infested bins containing live insects
1939 bins				
Butler	18	18	16	88
Calhoun	27	27	13	48
Cerro Gordo	24	24	15	62
Clarke	3	3	3	100
Franklin	31	31	29	93
Greene	10	10	10	100
Guthrie	8	8	5	63
Hamilton	21	21	14	66
Hardin	34	33	18	53
Louisa	12	12	10	84
Madison	27	27	22	82
Marion	18	18	18	100
Monona	26	26	17	65
Montgomery	10	10	8	80
O'Brien	12	11	9	81
Page	7	7	3	43
Plymouth	66	57	27	41
Polk	35	35	29	83
E. Pottawattamie	14	13	13	93
Sioux	14	13	5	36
Washington	22	22	20	91
Woodbury	11	11	6	54
Total	450	437	310	
1940 bins				
Butler	1	1	1	100
Calhoun	1	1	1	100
Guthrie	2	2	1	50
Hamilton	3	3	0	0
Louisa	1	1	1	100
Madison	28	27	19	67
O'Brien	2	1	1	50
Plymouth	37	30	21	57
Polk	3	3	3	100
E. Pottawattamie	20	15	10	50
Woodbury	2	1	0	0
Total	100	85	58	

Table 2.

A summary of data on the Number of live insects per sample in floor samples of bins being turned and cleaned, July, 1941

County	Number of bins containing live insects: Numbers of live insects per sample: 1	2-3	4-5	6-10	11-25	26-50	51-100	100 +	Total bins with live insects
1939 bins									
Butler	0	1	0	2	4	4	2	3	16
Calhoun	1	5	2	2	1	2			13
Cerro Gordo	2	5	0	2	3	0	0	3	15
Clarke					1	1		1	3
Franklin	2	2	1	6	14	3	1		29
Greene				2	1	3	3	1	10
Guthrie	0	2	0	0	0	1	1	1	5
Hamilton	4	3	1	3	2	1			14
Hardin	3	4	1	3	1	3	1	2	18
Louisa	1	1	0	1	3	1	2	1	10
Madison	0	3	1	5	6	3	3	1	22
Marion	0	2	2	2	5	3	3	1	18
Monona	1	5	3	1	4	2	1		17
Montgomery	1	2	1	3	0	1			8
O'Brien	1	2	1	2	1	1	1		9
Page	0	1	0	0	2				3
Plymouth	12	4	3	3	4	0	1		27
Polk	1	2	2	5	8	5	1	5	29
E. Pottawattamie	0	3	2	3	3	1	0	1	13
Sioux	1	1	1	1	1				5
Washington	1	3	1	2	2	4	6	1	20
Woodbury	3	0	1	2					6
Total	34	51	23	50	66	39	26	21	310
1940 bins									
Butler				1					1
Calhoun	1								1
Guthrie			1						1
Hamilton									0
Louisa		1							1
Madison	4	4	1	22	4	1		3	19
O'Brien	1								1
Plymouth	8	5	3	2	2	0	1	0	21
Polk		1					1	1	3
E. Pottawattamie	4	0	2	1	2	1			10
Woodbury									0
Total	18	11	7	6	8	2	2	4	58

Table 3.

A summary of data on the comparative abundance of stored grain pests in samples.

Species	Filled in 1939				Filled in 1940			
	No. of bins infested	No. of bins containing live insects	Percent dead*	Percent of bins containing live insects	No. of bins infested	No. of bins containing live insects	Percent dead*	Percent of bins containing live insects
Rust-red flour beetle	136	25	81	6.	8	4	50	4
Foreign grain beetle	353	46	87	10.0	43	15	65	15
Sawtooth beetle	237	172	27	38.0	29	19	35	19
Granary weevil	129	64	50	14.0	26	14	46	14
Rice weevil	19	1	95	0.2	12	0	100	0
Flat-grain beetle	275	190	31	42.0	29	19	35	19
Typhaea stercorea	334	55	84	12.0	49	15	69	15
Cynaeus angustus	154	48	69	11.0	4	1	75	1
Cadelle beetle	85	55	35	12.0	15	11	27	11
Black flour beetle	12	6	33	1.4	1	1	0	1
2-banded fungus beetle	64	13	80	3.0	8	0	100	0
Yellow-meal worm	20	2	90	0.4	4	0	100	0
Platydema ruficornis	15	2	87	0.4	2	0	100	0
Trogoderma versicolor	21	17	19	4.0	1	0	100	0
Black carpet beetle	11	4	64	1.0	1	0	100	0
Other dermestids	2	2	0	0.4	0	0	100	0
Spider beetles	22	1	96	0.2	4	0	100	0
Cryptophagus Sp.	146	20	86	4.2	12	3	75	3
Carpophilus sp.	42	3	93	0.6	7	1	86	1
Anthicus floralis	16	0	100	0	3	0	100	0
Litargus balteatus	63	12	81	3.0	10	3	70	3
Mycetophagus bipustullatus	69	16	77	4.0	3	0	100	0
Coninomus sp.	23	10	57	2.0	6	0	100	0
Indian meal W.								
Rust-red grain beetle								
Confused flour beetle								
Anthocorids	73	14	81	3.0	2	1	50	1
Hymenoptera	25	5	80	1.2	1	1	0	1
Grain mites		74		16.0		9		9
Book lice		23		5.0		1		1
Staphylinidae	37	6	86	1.4	9	3	66	3
Scarabaeidae	6	0	100	0	2	0	100	0
Mexican grain borer	5	2	60	0.4	4	2	50	2
Silphid	2	0	100	0	0	0	0	0
Nitidulids	3	2	33	0.4	8	1	87	1
Histerid	2	0	100	0	1	0	100	0

* Percent of infested bins in which all specimens were dead.

Table 4.

Summary of data for 762 bins on the numbers of bins where live insects were detected by five foot probe samples before and after cleaning.

County	No. of bins examined	No. of bins infested before turning	No. of bins infested after turning
Benton	19	5	1
Calhoun	27	3	1
Cerro Gordo	23	2	2
Clarke	7	2	0
Franklin	33	21	1
Guthrie	2	0	0
Hamilton	23	2	0
Hancock	42	5	4
Louisa	16	10	3
Madison	62	12	8
Marion	22	14	5
Monona	29	4	2
Montgomery	10	5	1
O'Brien	19	9	0
Page	7	0	0
Plymough	170	9	0
Polk	63	19	7
E. Pottawattamie	33	3	2
Sioux	71	9	1
Union	17	7	2
Washington	24	4	6
Woodbury	34	5	1
Wright	9	4	1
Total	762	134	49

Minnesota***

Screenings of corn from bins in 21 counties in Minnesota show that of 875 samples inspected 38.6 percent contained live insects whereas 16.8 percent contained no insects. Of the 13 species of insects represented in the samples the two most frequently found were the foreign grain beetle and the hairy fungus beetle. An analysis of the frequency of occurrence of the various species in the samples inspected is given below.

Table 5.

Species of insects found in corn screenings in Minnesota

Insect	Percent of samples in which present	
	Live and dead	Live only
Foreign grain beetle	65.9	10.3
Hairy fungus beetle	60.3	8.5
Flat grain beetle	24.2	15.8
Granary weevil	11.1	6.6
Sawtoothed grain beetle	8.9	5.3
Black flour beetle	6.9	3.7
Cynaeus angustus	5.0	1.1
Rust red flour beetle	5.0	2.3
Spider beetle	3.2	---
Rice weevil	1.6	0.2
Confused flour beetle	0.9	0.3
Cadelle	0.4	0.3
Small-eyed flour beetle	0.3	---

*** Reported by Dr. H. H. Shepard.

Summarized by counties to indicate the distribution of the five most common insect pests the data are presented in Table 6.

Table 6.

Samples of Minnesota corn screenings, 1941. (Summarized by counties and showing the number of samples containing live insects of several important species.)

County	Samples received	With granary weevil	With foreign grain beetle	With sawtoothed beetle	With flat grain beetle	With hairy fungus beetle
Big Stone	12	5	--	--	6	1
Blue Earth	79	3	16	2	8	9
Brown	1	1	--	--	--	--
Chippewa	68	4	2	1	5	2
Cottonwood	80	3	4	2	9	3
Freeborn	78	3	3	4	10	3
Jackson	186	--	9	--	24	23
Lac qui Parle	47	6	4	6	4	4
Lincoln	26	1	--	--	--	--
Lyon	77	1	8	1	11	5
Martin	4	--	--	--	1	--
Murray	48	1	2	1	--	1
Pipestone	18	--	--	--	--	--
Redwood	14	--	--	--	1	--
Renville	221	13	18	12	27	10
Rock	74	6	6	11	6	5
Sibley	2	--	--	--	--	--
Stevens	15	--	--	--	1	--
Traverse	26	4	6	--	2	3
Watonwan	11	--	2	--	2	--
Yellow Medicine	114	7	10	6	21	5

Samples were not received from 8 counties having steel bins as follows: Faribault, Kandiyohi, McLeod, Mower, Nicollet, Nobles, Olmsted, and Swift.

South Dakota****

Only a small number of samples of screenings from corn bins in South Dakota were available for examination. The species most commonly found were the flat grain beetle, the hairy fungus beetle and the sawtoothed grain beetle. The insects found and the frequency of occurrence is shown by the data of Table 7.

Table 7.

Species of insects found in corn screenings in South Dakota

Insect	Percent of samples in which found
Flat grain beetle	71.4
Hairy fungus beetle	71.4
Sawtoothed grain beetle	57.1
Grain mites	28.5
Corticaria serrata	28.5
Coninomus constrictus	28.5
Cryptophagus sp.	28.5
Enicmus minutus	28.5
Litargus balteatus	28.5
Granary weevil	14.3
Foreign grain beetle	14.3
Yellow meal worm	14.3
Confused flour beetle	14.3
Hymenopterous parasite	14.3
Lyctocoris sp.	14.3

**** Reported by Dr. H. C. Severin.

Effect of Temperature on Insect Abundance

Temperature readings in corn bins over the entire Commercial Corn Area are planned with the object of correlating this data with insect abundance. Due to the delay in obtaining wire for use as thermocouples this phase of the project has been somewhat delayed, but later reports will cover the subject fully.

A survey conducted in cooperation between the Entomology and Agricultural Engineering sections of the Iowa Agricultural Experiment Station and the State Agricultural Conservation Committee of the A. A. A. revealed some interesting information regarding the insect infestation present in corn bins in Iowa in early March, the degree of mortality occasioned by winter temperatures, and the temperature of the corn at the time of the survey. The following report of this work has been prepared by Geo. C, Decker of the Entomology Department of the Iowa Agricultural Experiment Station.

For the purpose of the Survey 2,000-bushel steel bins of corn in a number of widely scattered counties were chosen. Ten county committees were asked to cooperate and representatives of the state office and the Agricultural Engineering section took samples in three additional counties (Ida, Adair and Washington). In each county approximately ten bins were sampled. Samples from each bin were taken at six levels, namely; the surface, the floor, and one, three, six and nine feet below the surface. Temperatures were taken at each level sampled. All samples were shipped to Ames for examination where the Entomology section removed all of the insects present and classified them as to species and live or dead. The Agricultural Engineering section then graded the samples and listed the various graded factors.

The present report summarizes the information obtained bearing upon the insects encountered. As noted in Table 8 only 62 of the 138 bins examined contained live insects. Sixty-five bins had insects present all of which were dead and in 11 bins no insects were encountered. It is also interesting to note that insects sufficiently abundant to make the samples grade weevily were encountered in only five bins and only seven such samples appeared in a total of 306 samples which were graded.

In theory one might have expected live insects to appear most frequently near the floor in the center of the bin where the temperatures are highest. In reality, however, the results of the survey gave exactly the opposite result. Live insects were most frequently encountered in the surface layer. The number of bins yielding live insects at the various levels is shown in Table 9. Excluding the Indian meal moth which was almost universally present, the foreign grain beetle and the rust-red flour beetle were by far the most frequently encountered insects. In most of the bins all of the specimens of these species were dead. Even in the two bins where a few live red-rust flour beetles were taken over 95 percent of the specimens were dead. On the other hand such winter hardy species as the flat grain beetle, the sawtooth beetle, the cadelle beetle, and Cynaeus angustus which were less frequently encountered, usually showed considerably higher numbers of live insects. The relative abundance of the various stored grain pests is summarized in Table 10 and the geographical distribution of bins containing various species of live insects is shown in Table 11.

The average temperatures at the center of the floor for all of the bins in any individual county are tabulated below. It will be noted that the temperatures are lowest in the northern counties and from 8-10 degrees higher in southern counties. This would indicate that the degree of winter mortality one might expect would be considerably higher in the northern portion of the state and may be a very considerable factor in the natural control of such common pests as the foreign grain beetle, red-rust flour beetle, the granary weevil and the rice weevil.

Temperature of grain at center of floor of bins in various counties in Iowa. Temperatures represent the average for all bins tested in each county.

County:	Section of State	Average floor temperature (°F.)
Dickinson	NW	31.2
Cherokee	NW	37.7
Ida	WC	38.3
Crawford	WC	40.9
Floyd	NE	30.0
Hamilton	C	40.0
Benton	EC	39.1
Clinton	EC	39.1
Adair	SW	41.9
Mills	SW	48.4
Lucas	SC	40.0
Washington	SE	38.8
Louisa	SE	38.6

Table 8.

General summary of bins examined March 1-15, 1941 to determine the degree of insect infestation

No. of bins examined	138
No. of bins with no insects present	11
No. of bins with all insects dead	65
No. of bins with live insects	62
***	
No. of samples with no insects present	306
No. of samples with all insects dead	404
No. of samples with live insects	118
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No. of bins in which one or more samples graded weevily	5
No. of samples graded weevily	7

Table 9.

Relative occurrence of live insects at various levels in 2,000-bushel steel bins March 1 - 15, 1941

Position of sample	Approximate distance below surface	Number of samples containing live insects
Surface 2 inches	Surface	28
3 ft. probe--cells 1 & 2	1 foot	26
5 ft. probe--cells 5 & 6	3 feet	20
5 ft. probe--cells 9 & 10	6 feet	18
Extended probe--cells 1-4	9 feet	15
Extended probe--cells 7-10	Floor	11
Total infested samples		118

Table 10.

Data on the relative abundance of stored grain pests as found in the survey March 1 - 15, 1941

Species	No. bins with no insects	No. bins with all insects dead	No. bins with live insects
A. advena	78	60	
Sawtooth	102	29	7
T. castaneum	79	57	2
Laemophloeus minutus	88	17	33
Indian meal moth	31	104	3
Cynaeus angustus	101	25	12
Typhaea	119	19	
Cadelle	119	5	14
Granary weevil	131	7	
Rice weevil	133	5	
All	11	65	62

Table 11.

Distribution of bins containing live insects by species and counties, March 1 - 15, 1941

County	Species							
	Foreign grain beetle	Typhaea stercorea	Granary weevil	Rice weevil	Tribolium castaneum	Sawtooth beetle	Cynaeus angustus	Cadelle beetle	Flat grain beetle
Dickinson	0	0	0	0	0	0	0	0	1
Cherokee	0	0	0	0	1	0	5	0	0
Ida	0	0	0	0	0	0	0	0	1
Hamilton	0	0	0	0	0	1	0	0	5
Floyd	0	0	0	0	0	0	3	0	5
Crawford	0	0	0	0	0	1	0	1	2
Benton	0	0	0	0	0	1	0	2	7
Clinton	0	0	0	0	0	0	1	0	0
Adair	0	0	0	0	1	2	0	5	5
Mills	0	0	0	0	0	0	3	1	3
Lucas	0	0	0	0	0	1	0	1	1
Washington	0	0	0	0	0	0	0	1	1
Louisa	0	0	0	0	0	1	0	3	2
Total bins infested	0	0	0	0	2	7	12	14	33

Table 12.

Data on the number of bins infested by various species, by counties (Survey March 1-15, 1941)

(Both dead and live specimens included.)

County	Species								
	Foreign grain beetle	Typhaea stercorea	Granary weevil	Rice weevil	Tribolium castaneum	Sawtooth beetle	Cynaeus angustus	Cadelle beetle	Flat grain beetle
Dickinson	1	0	0	1	0	0	0	0	1
Cherokee	9	1	1	0	10	0	10	0	2
Ida	5	2	0	0	5	0	1	0	1
Hamilton	5	0	0	0	4	2	1	0	8
Floyd	10	1	0	1	4	0	8	0	6
Crawford	5	3	0	1	8	3	0	1	3
Benton	1	2	1	0	8	4	2	2	9
Clinton	3	1	0	0	2	0	2	0	0
Adair	3	1	0	0	7	7	3	5	6
Mills	6	4	0	1	5	7	6	2	7
Lucas	4	1	3	0	0	9	0	2	2
Washington	2	1	2	1	5	0	2	6	2
Louisa	6	2	0	0	1	4	2	1	3
Total bins infested	60	19	7	5	59	36	37	19	50

Fumigation*

Experimental work on the fumigation of corn has been continued and as usual the efficiency of the fumigant used was determined by planting in each bin treated an eleven foot probe containing 1½ oz. gelatin capsules in which insect infested grain had been placed. In some cases a second probe was placed diagonally across the bin as near the outside wall as possible. In most cases the probes were left in place for 72 hours before removal for examination.

Tests with the 3-1 mixture of ethylene dichloride and carbon tetrachloride plus ten percent methyl bromide.

Successful results with this mixture noted in our report for the previous quarter were confirmed by additional tests during the present quarter. The fact that a 2 gallon per thousand bushel dosage gave results comparable with the 6 gallon per thousand bushel dosage of the old 3-1 mixture resulted in the decision to recommend its substitution for the old mixture for the fumigation of all commodity credit corn during the present emergency caused by the shortage of carbon tetrachloride due to Defense requirements. Owing to the increased hazard to fumigators handling the new mixture it was recommended that all persons actively engaged in applying it be equipped with gas masks supplied with black canisters designed to protect the wearer against organic vapors.

The results obtained in current tests are given below:

No. bins treated	Dosage per 1,000 bus.	Amount of oil added	Results
5	1 gal.	None	2 bins 100% kill. Some life at top and bottom of 3 bins.
10	1 gal.	1½ gals.	3 with 100% kill.
10	1½ gals.	None	Some life in 4 bins.
5	1½ gals.	1½ gals.	Some life in 4 bins.
17	2 gals.	None	Some life in 3 bins.
34	2 gals.	1½ gals.	100% kill.

A two gallon dosage per 1,000 bushels plus 1½ gallons of oil gave consistently good results. Results of tests with other materials follow.

* Reported by Winburn, Magner, Farrar, and Dabney.

Tests with chloropicrin - carbon tetrachloride mixture

Additional tests were made with chloropicrin to determine its effectiveness when applied to the surface of bins of corn. The results obtained indicate that it is not practical to attempt to fumigate binned corn by applying the chloropicrin alone owing to the difficulty of obtaining adequate distribution of the vapors. By mixing the chloropicrin with carbon tetrachloride excellent results are obtained. The carbon tetrachloride appears to act as a carrier and a perfect kill was obtained with a dosage as low as 1½ pounds of chloropicrin per 1,000 bushels. The chloropicrin in this case was supplemented with 2 gallons of carbon tetrachloride.

No. bins fumigated	Dosage per 1,000 bushels	Amount carbon tetrachloride added	Results
2	1 lb.	2 gals.	100% kill.
1	1½ lbs.	2 gals.	100% kill.
4	2 lbs.	2 gals.	100% kill.
2	3 lbs.	2 gals.	100% kill.
1	3½ lbs.	2 gals.	100% kill.
1	3½ lbs.	None	Life in top and bottom cells of probe.

Tests with ethide (1, 1-dichloro-1-nitroethane)

Preliminary tests with this material during the previous quarter were so promising that experimental work with it was continued. It was found that as in the case of chloropicrin much better results were obtained if the material was applied with carbon tetrachloride. Results of the tests are shown below:

No. bins treated	Dosage per 1000 bushels	Amt. CCl_4 or other material added per 1,000 bushels	Results
2	1	2 gals. CCl_4	100% kill.
5	1½	2 gals. CCl_4	100% kill in 2 bins, life at top and bottom of 3 bins.
2	2	2 gals. CCl_4, 1½ gals. oil	Life in bottom of both bins.
2	2	2 gals. CCl_4	100% kill.
3	3	2 gals. CCl_4	100% kill.
1	3	2 gals. CCl_4, 1½ gals. oil	100% kill.
8	1	2 gals. 3-1 mixture of ethylene dichloride-CCl_4	1 bin 100% kill, rest incomplete.
5	1½	2 gals. 3-1 mixture of ethylene dichloride-CCl_4	3 bins 100% kill, rest incomplete.
2	None	2 gals. 3-1 mixture of ethylene dichloride-CCl_4	No kill.

Tests with carbon disulfide

One test conducted with carbon disulfide as a check, using a dosage of 3 gallons per 1,000 bushels gave a 100 percent kill.

Oil treatment of grain

In a further study of oils suitable for the surface treatment of bins of corn a number of different oils were applied by Messrs T. F. Winburn and E. V. Dabney during July. Samples of corn taken from these treated bins were inspected by the Federal Board of Review at Chicago, on August 16. Data regarding these tests are given in Table 13.

Table 13.

Bin No.	Date treated	Kind of oil	No. qts. applied	Gals. CCl_4 added	Condition of oil on surface	Grade
234	7-16-41	Prorex	4		Free oil spotted - heavy and medium	s. grade, musty odor
235	7-16-41	Prorex	6	2	Free oil heavy	" "
236	7-16-41	Prorex	4	2	Free oil light	" "
102	7-16-41	Tex. 522	4	2	Free oil light	s.grade,light oil odor
105	7-11-41	Tex. 519	8		Free oil heavy	" "
106	7-11-41	Tex. 1519	6		Free oil v. heavy trapped sev.C & YMW	" "
108	7-11-41	Tex. 1519	6		Free oil heavy	" "
109	7-11-41	D. P.	6		Free oil medium several IM	" "
110	7-11-41	D. P.	6	2	Free oil light	" "
112	7-11-41	Tex. 1519	6		Free oil heavy	" "
340	7-16-41	Conoco Redind	4		Free oil heavy	" "
342	7-16-41	Conoco Redind	2		Free oil medium to light	" "
350	7-16-41	Conoco Redind	4	2	Med. to light live IM on surface	" "
351	7-16-41	Conoco Redind	3	2	Free oil heavy	" "
454	7-16-41	Tex. 1519	4		Free oil v. light	" "
462	7-16-41	Tex. 1519	2		Heavy in spots, large bugs trapped	" "
463	7-16-41	Tex. 1519	4	2	Light trace free oil	" "
497	7-16-41	Std. Oil - Red Engine	?		Heavy but no depth	" "
498	7-16-41	Std. Oil - Red Engine	6	2	Med. to light	" "
499	7-16-41	Std. Oil - Red Engine	4		Medium	" "
100	7-16-41	Tex. 522	4		Heavy 1" deep	OK
101	7-16-41	Tex. 1519	6	2	Free oil medium	OK
103	7-16-41	Tex. 522	6	2	Free oil medium heavy Free oil on top	OK
104	7-16-41	Socony Protex	2		no depth Sur. very dirty	OK
107	7-14-41	Tex. 519	6		free oil med.	OK
111	7-11-41	Tex. 519	4	2	Free oil med.	OK

Table 13 continued

Bin No.	Date treated	Kind of oil	No. qts. applied	Gals. CCl_4 added	Condition of oil on surface	Grade
233	7-16-41	Tex. 522	2		Free oil med.	OK
348 & 455		CHECK BIN	- - - - - - - -		NOT OIL TREATED	
		Std. Oil				
500	7-16-41	Red Engine	4	2	Trace of free oil	OK
100	7-16-41	Tex. 522	4		Heavy 1" deep	OK
101	7-16-41	Tex. 1519	6	2	Free oil med.	OK
102	7-16-41	Tex. 522	4	2	Free oil light	Out
103	7-16-41	Tex. 522	6	2	Free oil med. heavy	OK
105	7-11-41	Tex. 519	8		Free oil heavy	Out
106	7-11-41	Tex. 1519	6		Free oil very heavy: trapped sev.C & YMW: Surface very oily	Out
107	7-14-41	Tex. 519	6		free oil med.	OK
108	7-11-41	Tex. 1519	6		Free oil heavy	Out
111	7-11-41	Tex. 519	4	2	Free oil med.	OK
112	7-11-41	Tex. 1519	6		Free oil heavy	Out
233	7-16-41	Tex. 522	2		Free oil med.	OK
454	7-16-41	Tex. 1519	4		Free oil very light: Heavy in spots-sev-	Out
462	7-16-41	Tex. 1519	2		eral large bugs trapped	Out
463	7-16-41	Tex. 1519	4	2	Light trace of free oil	Out

Wheat Storage

Experimental work in progress in connection with the storage of wheat has closely followed the plan outlined in the program of work. Owing to the difficulty of obtaining materials required for the work some delay was unavoidable in setting up the management series at both Jamestown, N. Dakota and Hutchinson, Kansas.

Jamestown, N. Dakota

Mr. George B. Wagner reports that no insects have been found in the wheat at Jamestown, North Dakota.

Hutchinson, Kansas*
Management Series

In accordance with the outline wheat in all but three of the bins in the management series were fumigated. Carbon disulfide was used at the rate of 3 gallons per 1,000 bushels, owing to the fact that other fumigants were not available.

The development of insect infestations in the untreated or check bins has been quite interesting. These 3 bins, 5-1, 6-1, and 6-2, were purposely left without treatment of any kind so that infestations naturally present at the time they were loaded would develop normally. The condition of the grain in these three bins at the time the bins were loaded and approximately 1 month later when they were probed is shown by the data of Table 14.

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* From report of R. B. Schwitzgebel.

Table 14:--Condition of wheat in check bins 5-1, 6-1, and 6-2 at time of loading and approximately 1 month later.

Bin No.	Sample	Grade	Moisture	Weight	Tot. Damage	Insects	Fore. Mat.	Dock.	Elevator	Date
5-1	Original	1HW	10.8	61	0.2	0	0.3	0.5	Farmer's Coop. (Haven)	6-13
	Probe	1HW	10.7	61	0.2	T	0	0.5		7-24
6-1	Original	2HW	11.1	58.4	0.3	0	0.5	0.6	Security	6-30
	Probe	2HW	11.4	58.5	0.4	T	0.4	0.6		7-24
6-2	Original	1HW	10.7	61.1	0.4	0	0.0	0.2	Farmer's Coop. (Haven)	6-12
	Probe	1HW	10.7	61.1	0.4	T	0.0	0.3		7-24

It will be noted that the moisture content of the wheat in bin 6-1 was higher than that of the other two bins and the wheat itself was from a different source. By mid September a sample of wheat taken from bin No. 6-1 contained 188 lesser grain borer adults and 4 rice weevil adults, whereas samples taken from the other two check bins showed no increase in infestation. Bin 6-1 was fumigated to prevent loss of the wheat.

Bins set aside for fumigation tests were not all fumigated at the time of loading and since experimental work on grain fumigants was delayed a certain number became infested before any treatment was given them. An indication of the abundance of insects developing in this wheat during the short period of storage (approximately 2 months) and the variety of species present is shown by the data of Table 15. These bins were all fumigated in September.

Table 15.

Infestation in special fumigation bins and 6-1 in mid September as indicated by insects in 1,000 gram samples of wheat.

Bin No.	Lesser grain borer	Rice weevil	Flat grain beetle	Cadelle	Confused flour beetle	Sawtoothed grain beetle	Totals
8-12	1	11					12
9-8	59	15	11		2		87
9-9	29	9	4				42
9-10	1	3	1				5
9-11	1		2				3
9-12	1		1		1		3
10-7	104	4		1			109
10-8	51	13	12				76
10-9	1						1
10-10	20	5	7			1	33
10-11	105	11	5			1	122
10-12	62	24	3				89
6-1	108	4					112

During the second week in September flights of the lesser grain borer (Rhizopertha dominica F.) were observed. The adults were found in large numbers on several of the bins especially bin 6-1. Those bins which had not been fumigated since filling seemed to be more attractive to the insects than those which had been fumigated. Also there seems to be some correlation between the bins with high infestations and those which were attractive to the borers, as indicated by the data of Table 16. Those insects crawling on the outside of bin 6-1 were first observed. Large numbers (500-1,000) congregated at the base of the bin and began crawling to the top which afforded the only entrance since the walls were caulked. Most of these insects were the lesser grain borer but there were a few rice weevil (Sitophilus oryza L.) and a few sawtoothed grain beetles (Oryzaephilus surinamensis L.)

Table 16.

Comparison of number of insects on outside bin walls to number per thousand gram sample in same bin

Bin No.	Approx. No. on wall	No. per 1,000 gr. of wheat
6-1	500-1000	113
9-8	500-750 (leaky door)	87
9-9	less than 50	42
9-10	less than 50	5
9-11	none	3
9-12	less than 50	3
10-7	100-200	109
10-8	100-200	76
10-9	none	1
10-10	100-200	33
10-11	100-200	122
10-12	100-200	89

Insect Traps

In order to determine whether or not insects were flying or crawling into the bins through the ventilators from outside sources, ventilation traps were constructed and installed in a 1,000 bushel bin of new wheat Bin 4-2 and in a 2,700 bushel bin of old wheat Bin 10-12.

The trap consisted of a galvanized sheet metal cone with a slant height of 20 inches and a 14 inch diameter. This cone was placed in an inverted position under the ventilator of each bin. Caulking compound was used to seal the spaces between the cone and the ventilator so that any insect entering the ventilator also came into the trap. A hollowed out jar lid was soldered on the end of the cone so a quart jar could be attached to the small end, to catch the insects.

Methods of collecting catches

A few grams of wheat were placed in the quart jar which was attached to the cone. At certain intervals as shown by the data of tables 17 & 18 the jar was removed, its contents emptied and counts of the insects made. Each time the jar was replaced on the trap a small quantity of wheat was placed in the jar. This wheat was always screened before use to prevent insects from being placed in the jar with the wheat. For several days of the month the trap was operated for 24 hours at a time. Part of the month collections were made at 8 o'clock in the morning and again at 5 o'clock the same day. By making collections at these intervals a record was secured of the insects entering the bin during the day and during the night separately. In Tables 17 and 18 figures in the column headed Hrs. are the time of day the trap was in operation. For instance 8-5 means the trap operated from 8 in the morning to 5 in the evening; 5-8 means from 5 in the evening to 8 in the morning.

Summary of collections

The trap in bin 4-2 was installed September 2 and operated until September 30. Thirty-five collections were made during this period. When the trap was started the weather was warm and the bin contained a quantity of wheat that was starting to heat. On September 5 the mechanical blower for cooling the grain in the bin was started and run for several days. During the period that the grain was heating and being cooled it was especially attractive to the foreign grain beetle, flat grain beetle, and the hairy fungus beetle. During the entire period the foreign grain beetle was trapped in the largest numbers with the flat grain beetle a close second. The data of Table 17 show the insects trapped and the numbers caught each day. A large number of book lice were trapped almost every day. Since they were wingless they either crawled up the sides of the bin and entered the ventilator or else were blown into the trap. Of the 72 parasites collected in the trap a species which appears to be Cephalonomia tarsalis (Ashm.) seems to be the most numerous. More than 100 unidentified specimens were collected representing orders Collembola, Diptera, Orthoptera, Coleoptera, Lepidoptera, Hemiptera, and Hymenoptera. A large percent of the unidentified specimens belong to the family Staphylinidae.

Table 17:--Collections of ventilator trap in bin 4-2 (new wheat)
September 2 to 30, 1941

Date	Hrs.	Number of insects: Foreign grain beetle	Flat grain beetle	Lesser grain borer	Indian meal moth	Hairy fungus beetle	Book lice (appr.)	Para-sites	Uniden-tified	Others
2-3	5-8	104	94	5	1	17			1	
3-4	8-5	10	82	14	1	69	50		17	
4-5	5-8	3	93	2		25		1	8	
5-6	8-8	46	36	2	1	104	100	27	15	
6-8	8-8	65	42	2		17	150	9	15	
8-9	8-8	18	11		1	1	200		2	Oecanthus
9-10	8-8	8	2			1	400	1	4	
10-11	8-8	13	7	1	1		300	4	3	
11-12	8-8	2	3				100	1	5	
12	8-5	2	2		1		50	1	1	
12-13	5-8	Lost								
13	8-5	17	4		4		150	1	10	Sawtooth g.b.
13-14	5-8	17	1				250		4	
14		Lost								
14-15	5-8	46	1		2		250	3	4	
15	8-5	16	8	1	6		100	4	5	
15-16	5-8	14	8				50		4	
16	8-5	46	16	35			200	1	1	Mites
16-17	5-8	5	11	1		1	200	1	2	
17	12-5	7	16	3			250	1	2	
17-18	5-9	24	4	1			200	1	5	
18	9-5	4	2				200	1	1	
18-19	5-8	18	5				100	2	1	
19	8-5	13	6				100		1	
19-20	5-8	10	5				200			
20-22	8-8	12	4				200	2	1	
22	8-5		9				200	1		
22-23	5-8		2				200			
23	8-5	2	1				100	2		Mites
23-24	5-8	1		1			100	3	1	
24	8-5	1					50	3		
24-25	5-5	2					100	1	1	
25-26	5-8	1					50		3	
26-27	8-5	None								
27-28	5-12	1								
28-29	12-3	1	1	7			300		2	
29-30	3-5		1	1				1		
Totals		529	477	76	18	224	4900	72	119	

The trap in bin 10-12 was operated from September 17 to September 25 at which time the bin had to be fumigated with carbon bisulphide because of the insect infestation. This bin was caulked at the roof-wall joint at the time the trap was installed to prevent the insects entering the bin except via the trap. The lesser grain borer was trapped in the largest numbers and hundreds of these insects were crawling over the bin in an effort to enter it for a week or two before the bin was fumigated. Book lice were trapped in greater numbers than they were in bin 4-2. The data in Table 18 show the kinds and numbers of insects collected from the trap, and the time of day when collected.

Table 18:--Collections from ventilator trap in bin 10-12 (1940 wheat) September 17 to 25, 1941

		Number of insects								
Date	Hrs.	Foreign grain Beetle	Flat grain beetle	Lesser grain borer	Indian meal moth	Hairy fungus beetle	Book lice (appr.)	Unidentified	Parasites	Others
17-18	2-9	10	1	30	1	2	200	3	1	Rice weevil
18	9-5	1	2	16			400	2	9	
18-19	5-8	2		26			300		3	Tar.plt.bug
19	8-5	1		4			200	1	1	
19-20	5-8	2	2	21		1	500			Rice weevil
20-22	8-8		4	74	1		1000	2	2	
22	8-5		1	36			500		7	
22-23	5-8			22			250			
23	8-5		2	18			500		2	Mites
23-24	5-8			53			200		1	
24	8-5	1		8	1		200	2		
24-25	5-8			5			150	2	1	
25	9:30	fumigated with carbon bisulphide								
Totals		17	12	313	3	3	4400	12	27	

Fumigation Tests

Fumigation tests with chloroethyl-formate in cooperation with Mr. H. D. Young indicated that a dosage of 2 gallons per 1,000 bushels failed to give satisfactory results.

Infestation in Wheat (General Observations)*

Indications are that conditions this season are highly favorable for insect development in farm stored wheat. Much of the wheat in Texas, Oklahoma, and Kansas was harvested with a high moisture content, a condition that is always dangerous.

Inspection of farm stored wheat in Oklahoma indicate that a very high percentage of farm bins are infested, in many cases making it extremely difficult to secure loans. The abundance of flying insects results in the rapid infestation of newly harvested and stored wheat.

In Kansas conditions are also causing concern, much farm stored wheat is infested and requires fumigation.

Infestation in Loan Wheat in Kansas

In connection with the inspection of loan wheat in Kansas, infested samples have been examined to determine the species involved and their abundance. Of 71 samples obtained from 33 counties, 57 were infested with the flat grain beetle. Other species in order of abundance were the sawtoothed grain beetle, the rice weevil, and the cadelle. In Table 19 data are given indicating the species present and the frequency of their occurrence.

Table 19.

Insects present in 71 samples of infested wheat from 33 counties in Kansas.

Insect species	Percent of samples in which present
Flat grain beetle	80.1
Sawtoothed grain beetle	33.8
Rice weevil	26.7
Cadelle	16.9
Granary weevil	12.6
Rust red flour beetle	9.8
Small-eyed flour beetle	9.8
Lesser grain borer	7.1
Foreign grain beetle	5.6
Confused flour beetle	2.8
Hairy fungus beetle	1.4
Black carpet beetle	1.4
Psocids	1.4

* Reported by R. T. Cotton.

Moisture requirements of grain infesting insects.*

That the percentage of moisture in stored grain is an important factor in detering or enhancing the development of insects has long been an accepted fact. Little, however, is known regarding the moisture requirements of the various individual grain-infesting insects. In order to determine the moisture requirements of our common stored grain pests for active breeding, a series of experiments were inaugurated with grain of different moisture content. Two cereal grains, namely, corn and wheat, were used in these tests, with six species of insects. The insects used were the black carpet beetle larvae, adults of the rice weevil, flat grain beetle, sawtoothed grain beetle, lesser grain borer and the confused flour beetle. One thousand grams of grain, and 50 insects were used in each test, the grain and insects being placed in 5 liter Erlenmeyer flasks fitted with rubber stoppers, glass tubes and rubber tubes, and connected in series to form a unified circuit. A constant relative humidity was maintained by drawing air through a solution of sulphuric acid of a density known to maintain the humidity desired. The bottle containing the sulphuric acid solution was connected with the series of Erlenmeyer flasks containing the grain and insects. Air suction was provided by means of a 5 gallon glass bottle fitted with a siphoning tube. Water siphoning from this bottle creates a suction, which draws the air through the sulphuric acid solution then through the series of flasks containing the grain and insects. Connected between the siphoning device and the series of grain containing flasks are two bottles, one empty, and the other containing a solution of sulphuric acid of the same density as used at the air intake. This arrangement prevents any moist air from being drawn back into the flasks should anything go wrong with the apparatus. By regulating the flow of water through the siphoning tube, a constant passage of humidity regulated air was maintained in the flasks. Repeated moisture determinations of the grain involved show that the moisture remains constant with this equipment.

Up to the present time tests have been conducted for 19 weeks with wheat and corn of 7, 8, 9, and 10 percent moisture content and for 9 weeks with wheat and corn of 9½ and 11 percent moisture content.

The survival of the six species of insects referred to in the grain of different moisture content is shown by the data of Tables 20-25.

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* From report of J. C. Frankenfeld, U. S. Bureau of Entomology and Plant Quarantine.

Three species, the rice weevil, the flat grain beetle, and the lesser grain borer, failed to survive for more than a week in 7 or 8% moisture wheat or corn. The sawtoothed grain beetle showed somewhat greater resistance in 7 and 8% moisture grain than the aforementioned species, but only a small percentage survived for more than 3 weeks.

In the case of the black carpet beetle larvae and adults of the confused flour beetle, a much higher survival was observed. These two species are apparently able to subsist on grain with a very low moisture content, and it is entirely likely that the mortality observed may have been due to other factors.

With 9% moisture grain the length of survival was increased in all cases except with the lesser grain borer.

Although the tests show that certain grain infesting insects can survive in corn or wheat with a moisture content of 9% or less no reproduction was observed.

With grain of 9½ moisture content all species with the exception of the rice weevil and the granary weevil experimented with reproduced in both wheat and corn.

The rice weevil reproduced itself in corn with a moisture content of 10% but not in wheat of that moisture content. Throughout the tests it was noted that a considerable higher percentage of survival occurred in corn than in wheat.

In general the higher the moisture content of the grain the more rapid the development of all species.

Table 20:--Percentage of survival of various stored grain insects reared in 7% moisture grain.

Insect used and food	Percentage of survival after 1 Week	3 Wks.	5 Wks.	7 Wks.	9 Wks.	11 Wks.	13 Wks.	15 Wks.	17 Wks.	19 Wks.
Black carpet beetle--corn	88	81	79	77	73	70	70	70	68	68
--wheat	100	98	96	94	94	90	90	90	90	90
Rice weevil--corn	0	0	0	0	0					
--wheat	0	0								
Flat grain beetle--corn	0									
--wheat	0									
Confused flour beetle-corn	92	74	68	64	52	40	36	34	34	34
-wheat	92	70	56	34	16	4	0			
Sawtoothed grain beetle--										
corn	16	10	8	8	8					
wheat	13	0								
Lesser grain borer--corn	0	0								
--wheat	10	0								

Table 21:--Percentage of survival of various stored grain insects reared in 8% moisture grain.

Insect used and food	Percentage of survival after 1 Week	3 Wks.	5 Wks.	7 Wks.	9 Wks.	11 Wks.	13 Wks.	15 Wks.	17 Wks.	19 Wks.
Black carpet beetle--corn	42	22	22	22	22	22	22	22	22	22
--wheat	100	98	98	98	98	98	98	98	98	98
Rice weevil--corn	0									
--wheat	0									
Flat grain beetle--corn	0									
--wheat	0									
Confused flour beetle-corn	96	72	60	54	46	46	32	30	28	22
-wheat	100	100	100	94	84	70	44	28	24	8
Sawtoothed grain beetle--										
corn	0									
wheat	62	30	12	2	0					
Lesser grain borer--corn	0									
--wheat	16	4								

Table 22:--Percentage of survival of various stored grain insects reared in 9% moisture grain.

Insect used and food	Percentage of survival after									
	1 Week	3 Wks.	5 Wks.	7 Wks.	9 Wks.	11 Wks.	13 Wks.	15 Wks.	17 Wks.	19 Wks.
Black carpet beetle--corn	100	86	64	48	30	28		20	20	20
--wheat	100	88	60	44	26	24		20	18	18
Rice weevil--corn	26	12	12	12	2	0				
--wheat	4	0								
Flat grain beetle--corn	0									
--wheat	2	0								
Confused flour beetle-corn	100	86	84	84	80	74		72	70	70
-wheat	98	70	70	68	66	66		60	60	50
Sawtoothed grain beetle--										
corn	74	58	58	58	56	56		54	54	40
wheat	86	64	64	64	64	64		44	34	8
Lesser grain borer--corn	0									
--wheat	0									

Table 23:--Percentage of survival of various stored grain insects reared in 10% moisture grain.

Insect used and food	Percentage of survival after									
	1 Week	3 Wks.	5 Wks.	7 Wks.	9 Wks.	11 Wks.	13 Wks.	15 Wks.	17 Wks.	19 Wks.
Black carpet beetle--corn	100	100	100	100	100	100	100	100	100	96
--wheat	100	100	100	100	100	100	100	100	100	100
Rice weevil--corn	100	100	94	90	90	84	82	72	58	52
--wheat	98	88	88	60	8	0				
Flat grain beetle--corn	100	96	82	66	64	60	56	46	32	18
--wheat	100	90	20	0						
Confused flour beetle-corn	100	100	98	98	98	98	96	90	76	76
-wheat	100	90	88	88	80	72	56	54	44	34
Sawtoothed grain beetle--										
corn	98	94	82	78	78	74	70	70	70	70
wheat	96	92	78	70	42	28	8	0		
Lesser grain borer--corn	80	68	46	44	42	36	34	34	34	26
--wheat	88	66	44	40	34	28	28	26	4	0

Table 24:--Showing the percentages of survival of various stored grain insects when reared in 9.5% moisture corn and wheat.

Insects and Food	Percentage of survival after 1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks
Granary weevil--corn	98	92	82	70	64
--wheat	78	66	56	24	22
Rice weevil--corn	70	60	40	32	30
--wheat	2	0	0	0	0
Confused flour beetle--corn	98	92	90	90	88
--wheat	96	92	92	92	92
Rust red flour beetle--corn	96	90	86	80	74
--wheat	96	90	88	88	84
Sawtoothed grain beetle--corn	100	94	72	62	58
--wheat	100	96	90	84	84
Lesser grain borer--corn	64	50	38	28	12
--wheat	76	68	68	68	68

Table 25:--Showing the percentage of survival of various stored grain insects when reared in 11% moisture corn and wheat.

Insects and Food	Percentage of survival after 1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks
Black carpet beetle--corn	100	100	100	98	92
--wheat	100	96	96	96	44
Rice weevil--corn	100	100	96	94	92
--wheat	100	100	100	68	22
Flat grain beetle--corn	100	92	86	80	60
--wheat	92	72	42	8	0
Confused flour beetle--corn	100	98	94	94	94
--wheat	98	98	98	98	98
Sawtoothed grain beetle--corn	100	94	88	72	12
--wheat	94	78	34	10	0
Lesser grain borer--corn	96	68	28	20	18
--wheat	90	70	24	16	16